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Biochar: Production, Characterization and Applications

Proceedings

8-20-2017

Biochar characterization and EU27 law harmonization: REFERTIL results

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Biochar characterization and EU27 law harmonization: REFERTIL results

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Alba, August 22nd 2017

WHAT IS AGROINNOVA

Agroinnova is a **Centre of competence** established at the University of Torino in 2002.

Agroinnova carries out **basic and applied research**, as well as **knowledge and technology transfer, life-long learning and communication** on up-to-date topics in the **agro-environmental** and **agro-food** sectors.

The REFERTIL project

The REFERTIL partnership is bringing experts, researchers and SMEs industrial partners from a variety of sectors together with local stakeholders.

Participant organization	Country	Activity
TERRA HUMANA Kft. - Coordinator & biochar key tech RTD + designer	HU	Company
Plant Research International, Wageningen	NL	RES
Aarhus University	DK	University
The Knowledge Centre for Agriculture	DK	Advisory Centre
University of Torino, Agroinnova	Italy	University
Gottfried Wilhelm Leibniz Universitaet Hannover	DE	University
Biomasa del Guadalquivir S.A.	E	**SME**
WESSLING Lab Hungary Kft.	HU	Company
KOTO d.o.o.	SLO	**SME**
Comune di Grugliasco	Italy	City Council
Renetech Bioresources Ltd.	IRL	**SME**
Profikomp Zrt	HU	**SME**

The **REFERTIL** project focused on:

- recycling of byproducts and bio-wastes into safe biochar and compost that **reduce the dependence on mined, non- renewable & imported Phosphorus/Nitrogen supply**,
- **developing science & proven industrial technology** for safe & economical transformation of the organic by-product/waste streams from Europe's agriculture and food industries,
- contributing to the **international standardization and legal permitting of biochar/compost** products, and
- biochar/compost **policy support** to the European Commission DG GROW + other DG's for **FERTILIZER REGULATION revision** and **EU27 law harmonization.**

What is biochar?

BIOCHAR MATERIAL is:

- **plant and/or animal bone biomass origin,**
- **stabile carbon** carboniferous material,
- used for **mandatory EU/MS Authority permitted** ecological soil enhancement, and eco-safe carbon negative applications.

BIOCHAR PRODUCT is:

- a **labeled** and full value chain safe product,
- having **producers product responsibly guarantees**,
- meets all the **EU/MS product criteria for production and product permits (including REACH).**

INPUT SUSTAINABLILITY CRITERIA: The feed material:

- **not from primarily** and secondarily **land use**,
- **not competing with human food and animal feed,**
- **having environmentally sustainable logistics**.

How biochar is made?

- **BIOCHAR PROCESSING:** pyrolysis – carbonization process in **reductive** (indirectly heated) **thermal conditions,** 450°C - 850°C (usually around 550°C material core).

- **ABC** Animal Bone bioChar processing **require by higher efficient thermal processing, complex and higher level of technology, than PBC Plant Based Biochar.**

„3R"
Recycle
Reuse
Reduce
zero emission technology

There is no one fit for all biochar technology solution

The REFERTIL technology

Recycling of concentrated natural Phosporus bio-fertilizer

REFERTIL

"3R" ZERO EMISSION CARBON BIO-REFINERY

FOOD GRADE BONE CHIPS

Process gas CATALYTIC CONVERSION

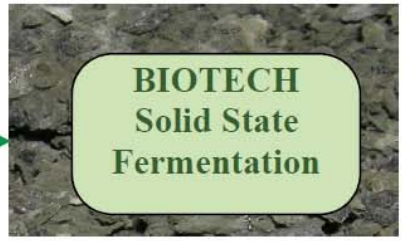
Recycled energy

REFINED BIO-OIL

RECYCLED NITROGEN

ADSORBENT
Environmental and industrial applications, water treatment

ANIMAL BONE BIOCHAR
C=(~8-12 %), $Ca_3(PO_4)_2$ = (~ 92%)



FORMULATED ABC
NPK-C

EFFECTS:

- Full value organic P fertilizer.
- Enhanced productivity.
- Nutrient & moisture retention.
- Improved soil life.
- N_2O mitigation.
- Cation Exchange Capacity ↑

DIRECT SOIL APPLICATION

COMPOST ACTIVATOR

DROUGHT TOLERANT HORTICULTURE
ORGANIC/LOW INPUT FARMING

www.agrocarbon.com
www.refertil.info

Biochar quality engineering

Plant based biochar (PBC)

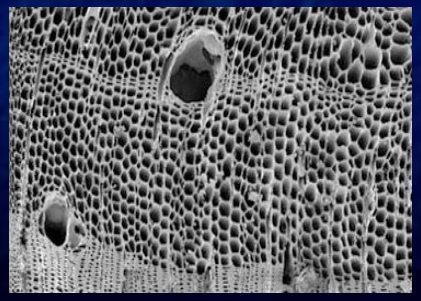
Soil improver, growing media

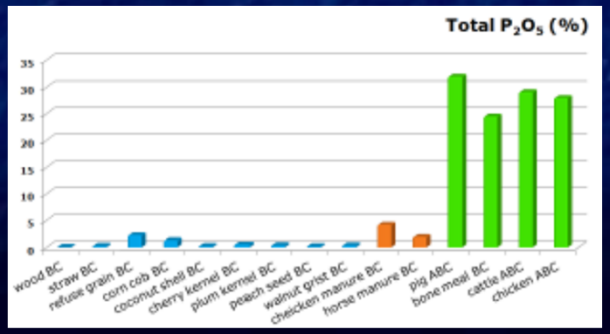
- Made from plant based biomass materials
- > 90% stabile C content
- High water holding and nutrient retention capacity but, neglible P and Ca content (no direct soil fertilization effect)
- **Dose: 3t/ha - 20 t/ha**

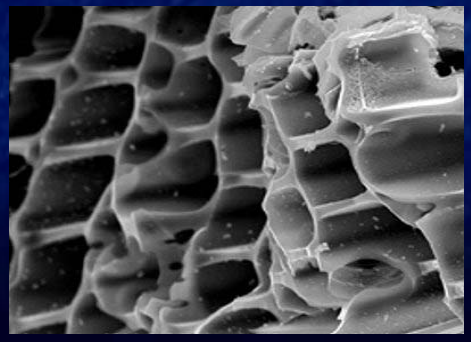
Animal Bone bioChar (ABC)

Organic Phosphorus fertiliser, soil improver, growing media

- Made from food grade category 3 bones
- 90% mineral content – 10% C
- 30% P_2O_5 + 38 – 42 **%** CaO, Mg, K
- Slow release direct organic fertiliser
- **Dose: 0.2t/ha - <1 t/ha**







PCB: micro – mesoporous 1-50 nm

ABC: macroporous 50 nm– 63,000 nm

Natural science result scale up system

Biochar TRL technology readiness levels Commission Decision C(2013)8631		TRL Implementation factor %	TRL Implementation risk %
Research and development steps	TRL 1-3 IDEA (basic principles, technology concept formulated)	0-1%	99-100%
	TRL 4 technology validated in LAB	0-3%	97-100%
	TRL 5-6 PILOT technology validated and demonstrated (high technical risk/full commercial risk)	10-25%	90-100%
	RTD risk break-even point		
	TRL 7 system PROTOTYPE demonstration in operational env.	60-75%	40-70%
	TRL8 FIELD DEMO system complete and qualified	**75-90%**	**15-25%**
Ultimate RTD stage **conversion of science into practice =** **TRL 9 competitive manufacturing**		**95-99%**	**1-5 %**

REFERTIL BIOCHAR after TRL 8 before TRL 9

Biochar policy support

REFERTIL Objective: providing a strong policy support for the EU Commission in revision of the Fertiliser Regulation (Reg. EC No. 2003/2003) and possible inclusion of biochar - as safe organic fertiliser and soil additive.

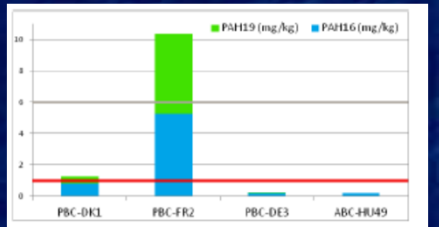
271 pages biochar policy support report submitted to the EU Commission:

- Integration of the REFERTIL biochar applied scientific research, industrial engineering, legal and economical aspects.
- Uniting all the knowledge and experience generated during the REFERTIL project time.
- Biochar legal aspect overview and evaluation.
- Biochar economics sustainability evaluation under market based commercial conditions.
- **Development of harmonized and standardized analytical measurements for determination of the physic-chemical properties, potentially toxic element content and organic pollutants in the biochar materials.**

Biochar policy support

RATIONALE FOR REFERTIL RECOMMENDED LIMIT VALUES AND QUALITY CRITERIA FOR BIOCHAR PRODUCTS

1. **SAFETY & QUALITY:** There should be no overall adverse environmental, ecological and human health impact from the use of biochar products in the open soil environment:
   - Clear and strict definition of the biochar product quality. → **N-P-K minimum nutrient content key indicator.**
   - Clear and strict definition of the limit values for contaminants:
     - **PAHs: Target pollutants - key indicator.**
     - **Potential toxic elements:** target pollutants key indicator.
     - **PCB_7:** indicator also for PCDD/F.



Comparison of PAH16 and PAH19 content of ABC and different plant based biochars

2. **MARKET REGULATION:** poor quality biochar products must be excluded from the market.
3. **AUTHORITY CONTROL**: Authority permits (according to EU/MS regulations) + REACH for production and use biochar over 1 t/y capacity.
4. **BIOCHAR PRODUCTION** criteria for safe biochar production.
5. **BIOCHAR ECONOMY**: realistic and commercial market demanded economical scenario.

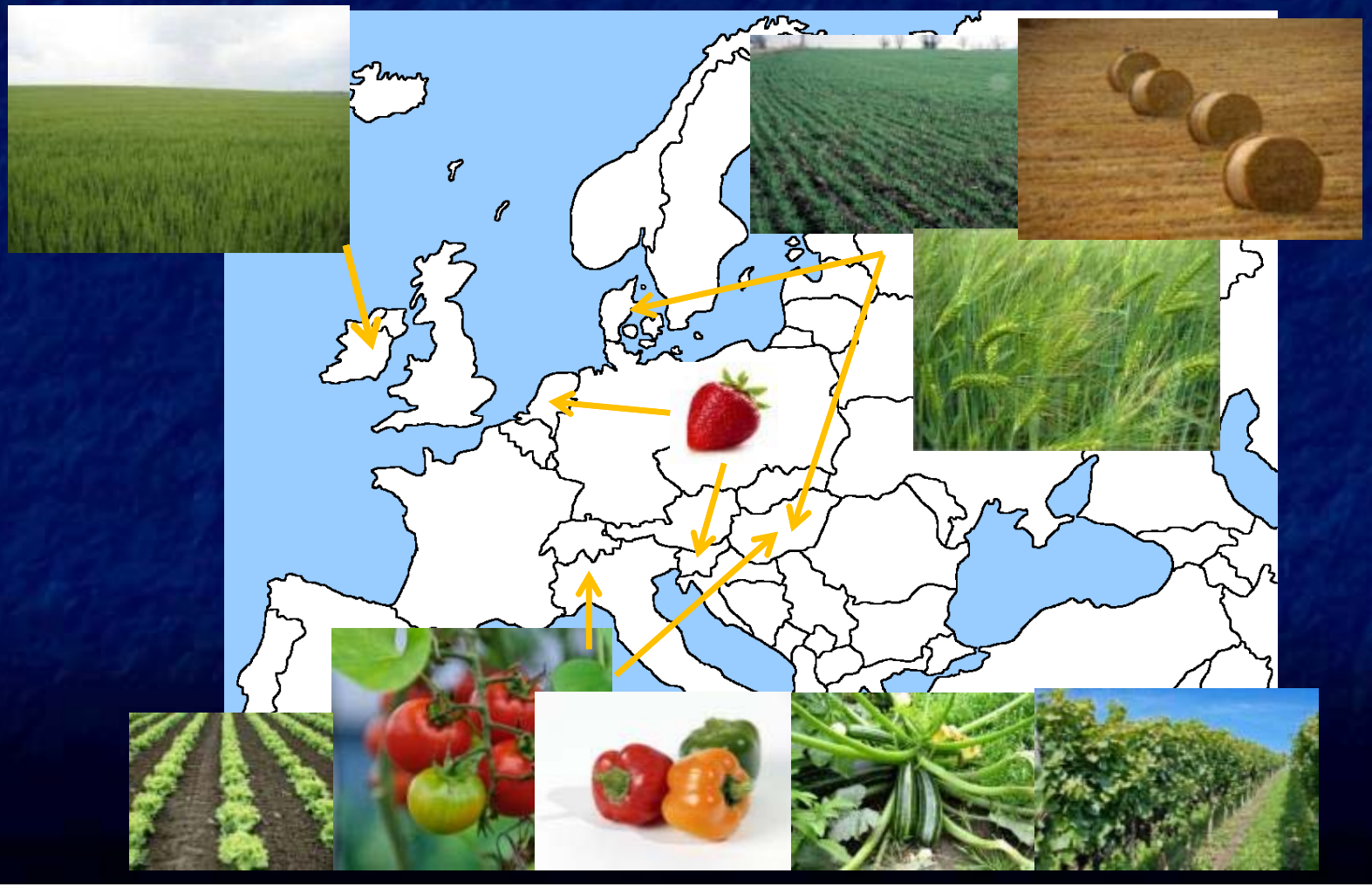
Biochar policy support

REFERTIL RECOMMENDED BIOCHAR QUALITY PARAMETERS & NUTRIENT CONTENTS

The REFERTIL partner "The Environmental Testing Laboratory of WESSLING" is the first laboratory in Europe who obtained accredited status for comprehensive analyses of biochar samples.

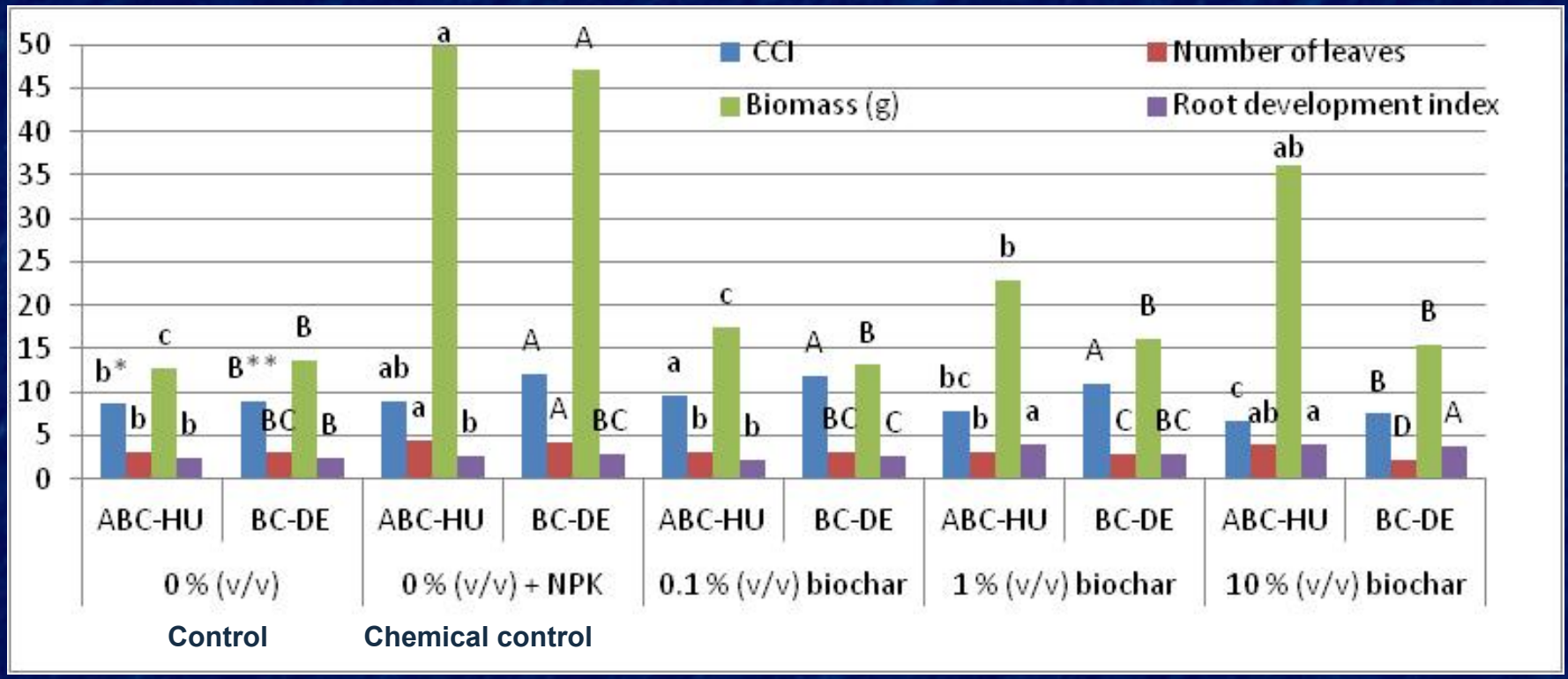
Biochar parameters	ORGANIC P-FERTILISER	SOIL IMPROVER
Potential toxic elements (mg/kg)		
As	10	10
Cd	1.5	1.5
Cr	100	100
Cu	200	200
Pb	120	120
Hg	1	1
Ni	50	50
Zn	600	600
Organic pollutants		
PAH 16	6	6
PCB 7	0.2	0.2
PCDD/F (ng/kg I-TEQ)	20	20
Particle size distribution	ABC: 1-5mm, 90%	PBC: 1-20 mm, 90%
Bulk density	declaration	declaration
Dry matter content	>80%	>60%
pH	6 - 10	6 - 10
Total Organic C	declaration	20%
N and K total	declaration	declaration
Total P (P_2O_5)	>25%	declaration
Total Ca, Mg	declaration	declaration
Germination inhibition assay	No inhibition	No inhibition
Phytotoxicity	No phytotoxicity	No phytotoxicity
Agronomic efficiency	Should be proved	Should be proved

Biochar policy support: field trials on the use of biochar



Biochar use

Effects of two types of biochar applied to a soil on cucumber



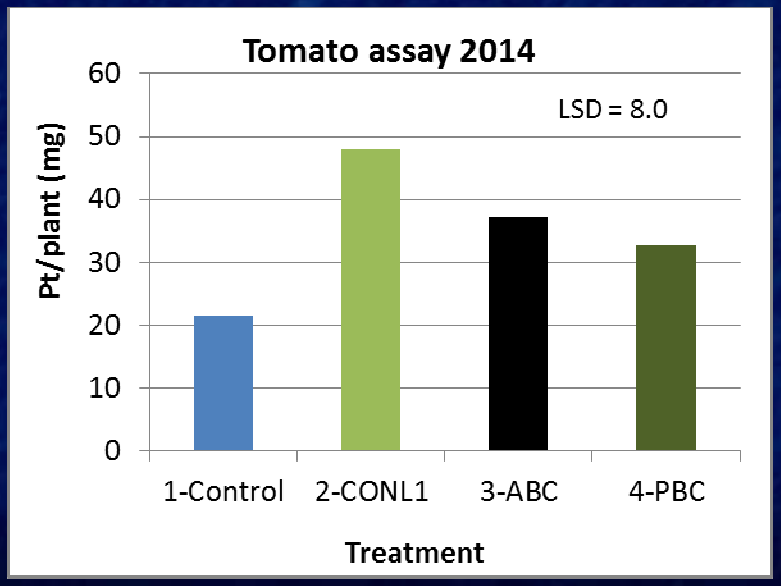
*Tukey's HSD (P<0.05), for values belonging to the group ABC-HU (animal bone char)
** *Tukey's HSD (P<0.05) for values belonging to the group BC-DE (plant based biochar)

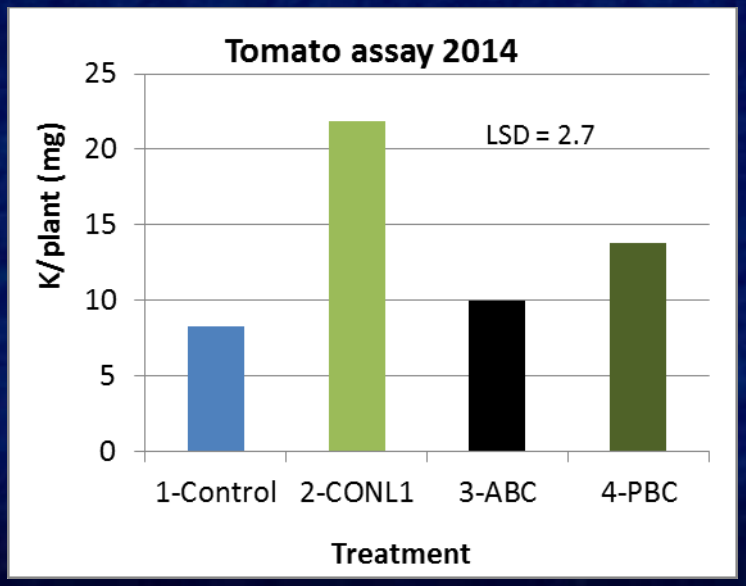
Increased CCI by animal bone char: biostimulation and plant growth promotion

Fertilization effect at higher dosages

Growth of plants

- Increased P uptake with compost, ABC, BCDE
- Increased K uptake with compost, BCDE
- Same results in 2014 & 2015

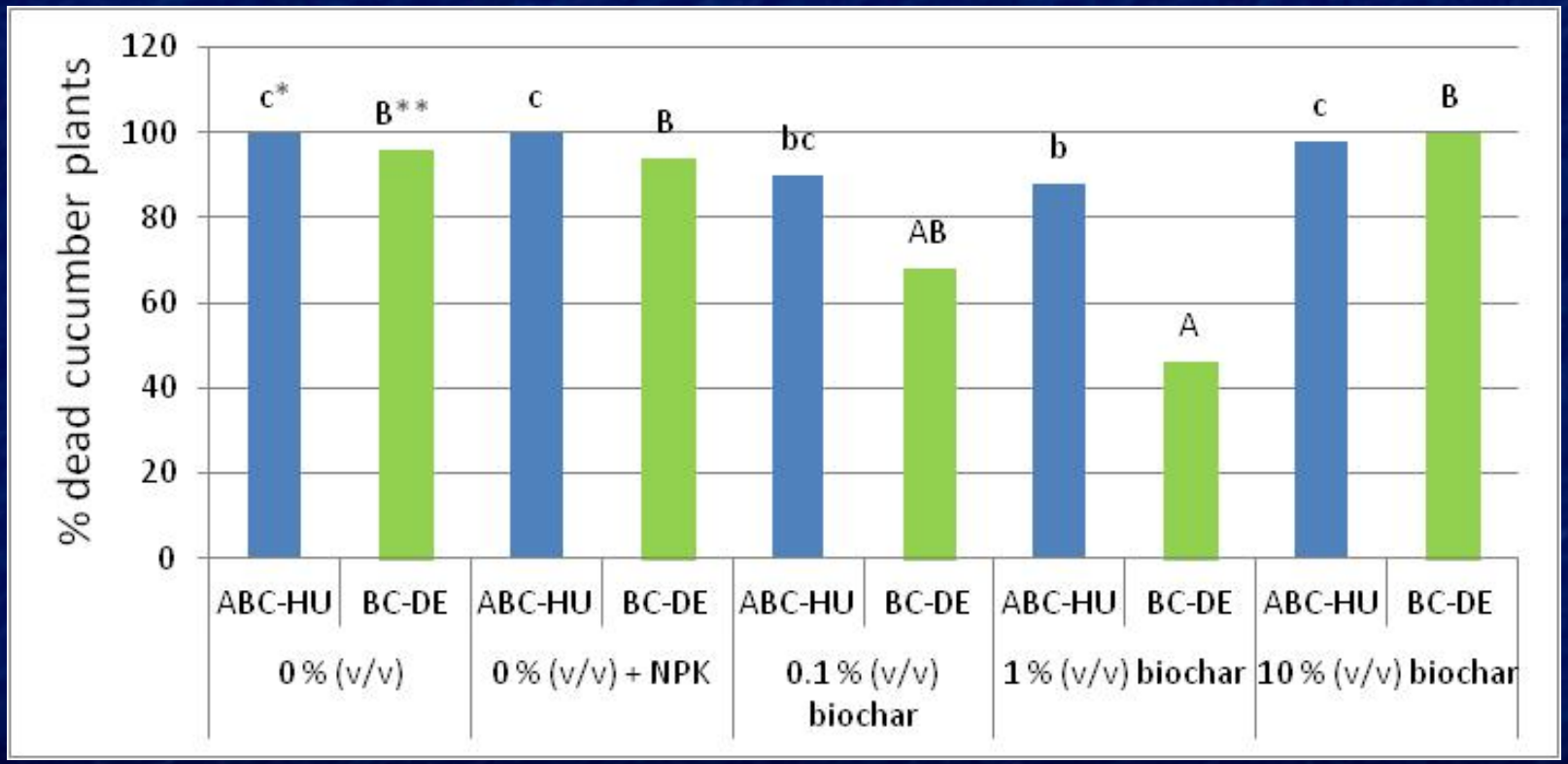




Courtesy of Dr. Joeke Postma, Wageningen University

Biochar suppressiveness on vegetable crops in pots

Effects of two types of biochar applied to a soil against *Pythium ultimum* on cucumber



*Tukey's HSD (P<0.05), for values belonging to the group ABC-HU (animal bone char)
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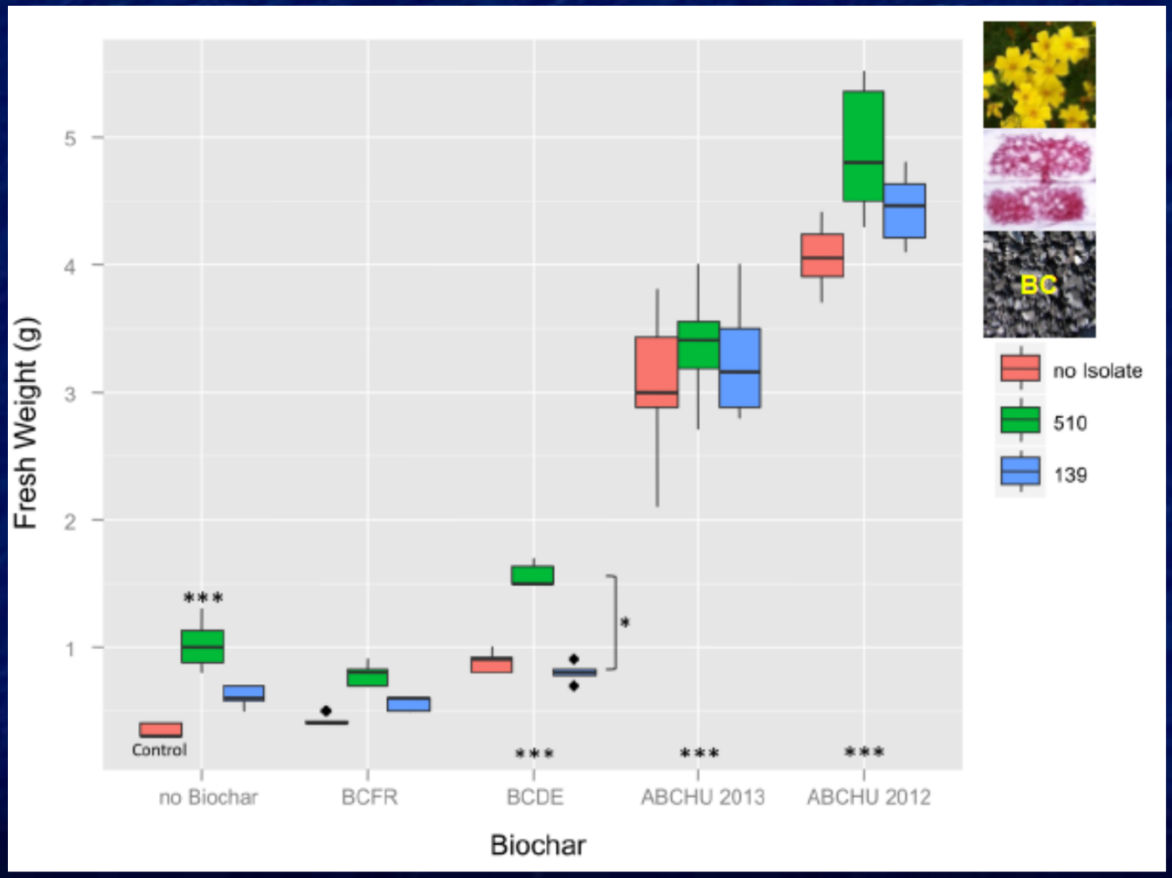
Microbiologial enrichment of biochar

Selected mycorrhial fungi can be combined with biochars and usefully applied in agri- and horticulture



Shoot growth (±SE) of *Tagetes erecta* cv. Luna Lemon grown in quartz sand, inoculated or not with *G. intraradices* (510) or *G. etunicatum* (139). All plants fertilized without P. With and without 2% (v/v) of 4 biochars. Significance codes: 0 '*' 0.001 '**' 0.01 '*'**

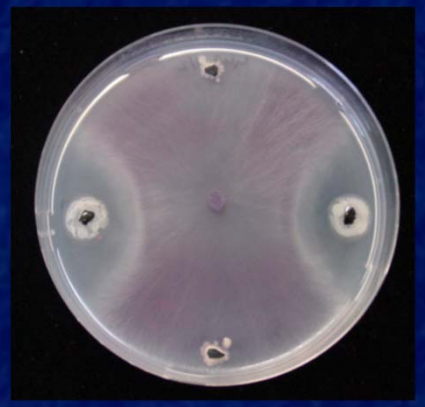
Courtesy of Prof. Henning von Alten, Leibniz University of Hanover, Germany

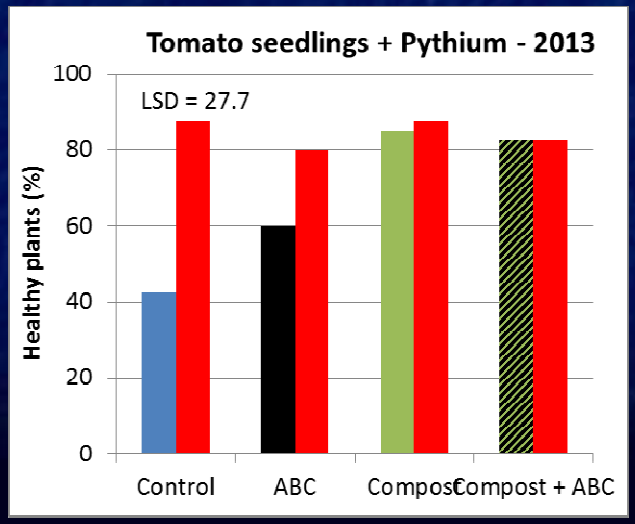
Microbiologial enrichment of biochar

Addition of antagonists using:

- Compost
- Animal bone char
- Seed treatment

Pseudomonas chlororaphis 4.4.1
In vitro inhibition of fungi
Solubilizes P
Good root colonizer
(Postma *et al.*, 2013)



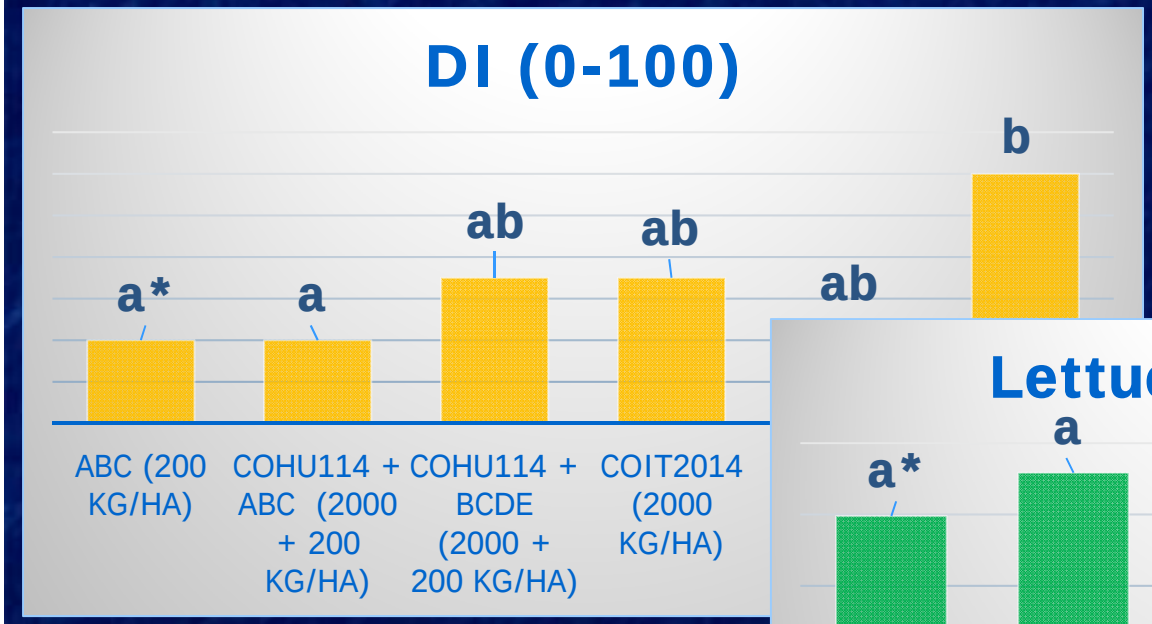


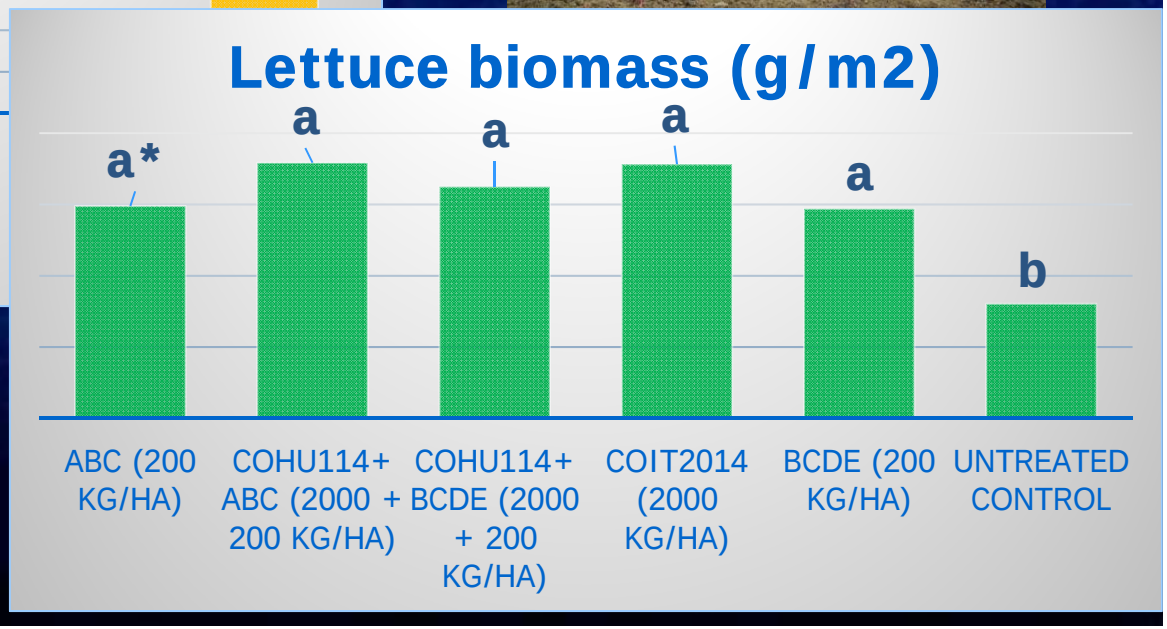
Addition of *Pseudomonas chlororaphis* 4.4.1 improved the suppressiveness of the control potting soil and ABC amended potting soil

Courtesy of Dr. Joeke Postma, Wageningen University

Integration of the use of biochar and compost in field

Biochar and compost tilled into the soil before transplanting





*Tukey's HSD ($p<0.05$)

REFERTIL outcomes

- EU available and economically important **bio-waste feed materials characterization.**
- **BAT technical-economical-enviro evaluation** of **7 biochar** and **15 compost** treatment technologies.
- **2000 tons** input bio-waste treatment from which 600 tons different types of high quality compost production.
- **100 m3** of different types of biochar production from different inputs.
- **Three economically important food crop plant growth field tests** in 6 counties.
- **Completed biochar full industrial production technology,** development of **EU/MS mandatory permit schedules.** Conversion of science into economical technology knowledge.
- **Fertilizer Regulation revision policy support.**

Thank you

The REFERTIL (289785) Collaborative project is co-funded by the European Commission, Directorate General for Research, within the 7th Framework Programme of RTD, Theme 2 - Food, Agriculture and Fisheries, and Biotechnology.

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